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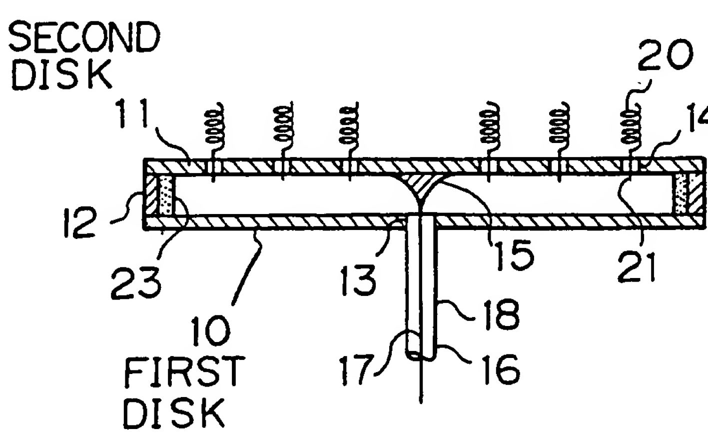
INT CL[4] H01Q

(54) **A circular polarization antenna system**

(57) A circular polarization antenna system has a thin cylindrical antenna body bounded by a pair of parallel conductive disks (10, 11) short-circuited by a conductive ring (12) at their periphery so that the disks are spaced by less than a wavelength. A plurality of antenna elements (20) are located on one of the disks (11) and feed means (16) are coupled to the centre of the other disk (10). The antenna system has high gain because of the use of many antenna elements, and wide operational frequency band as the antenna elements are energized by travelling wave (TEM mode), whilst being small in size. The antenna elements may be helical, spiral or be formed by flat disks.

Fig. 2



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy

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Fig. 1

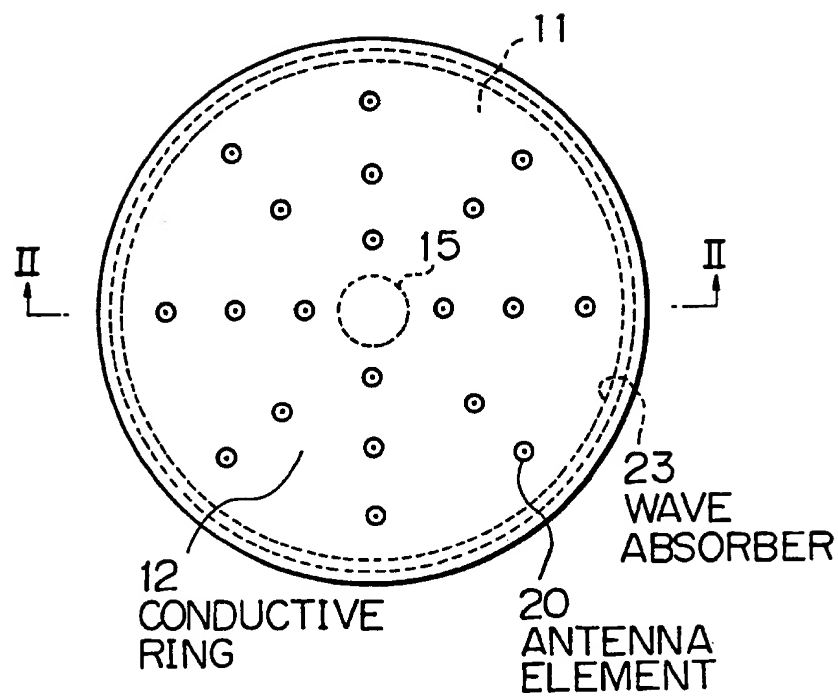
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Fig. 2

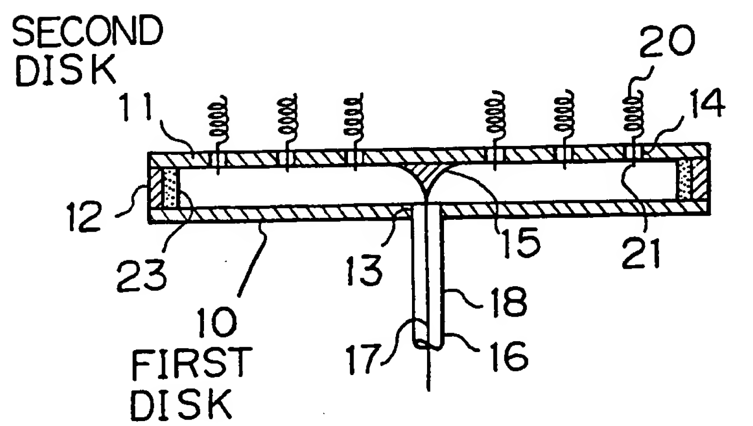
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Fig. 1

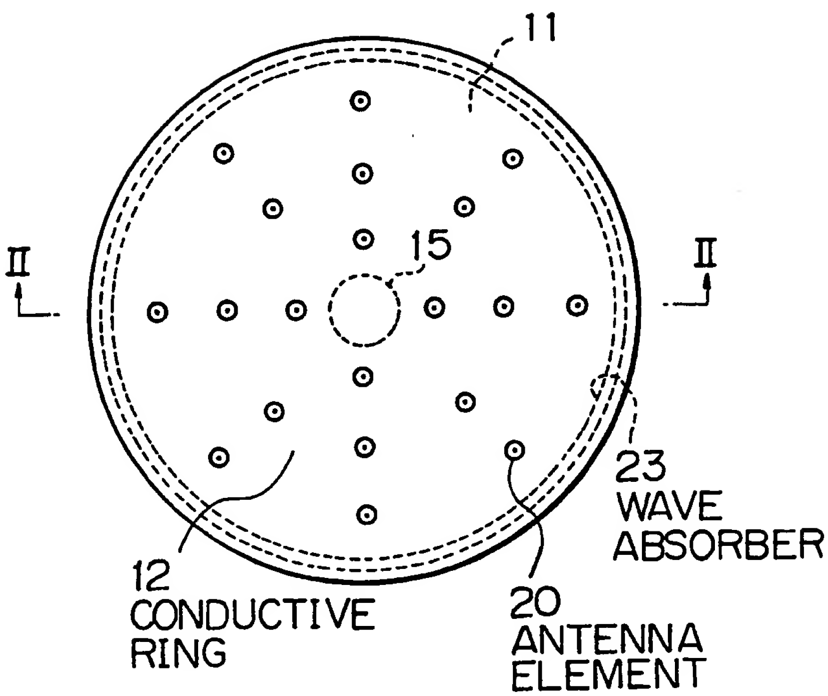
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Fig. 2

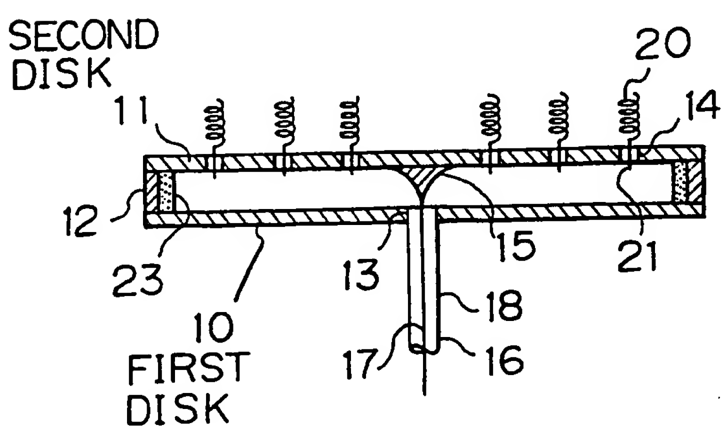
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Fig. 3

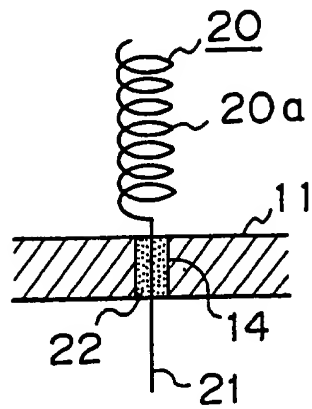


Fig. 4

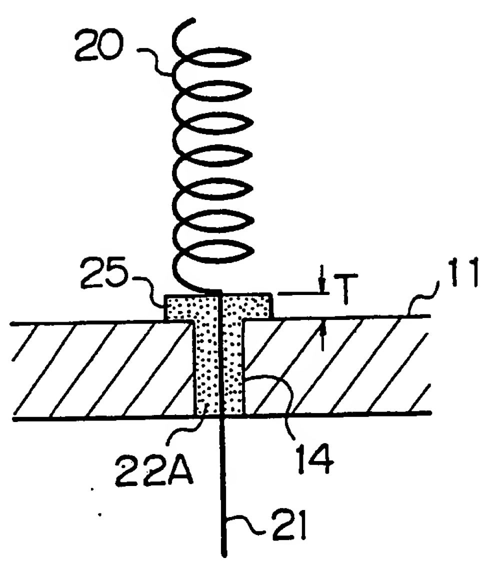


Fig. 5

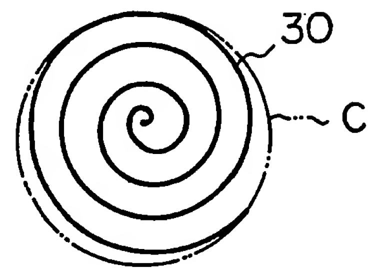


Fig. 6

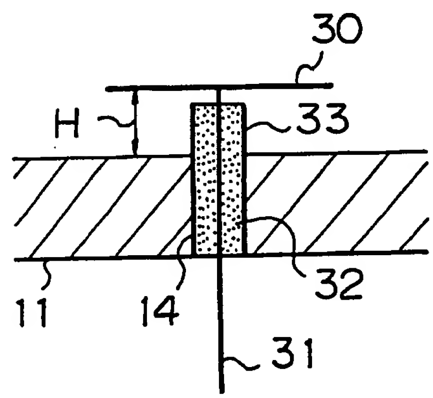


Fig. 7

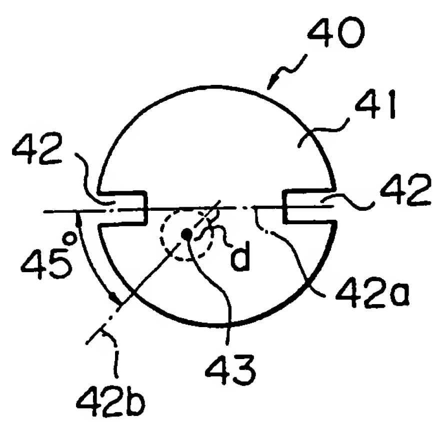


Fig. 8

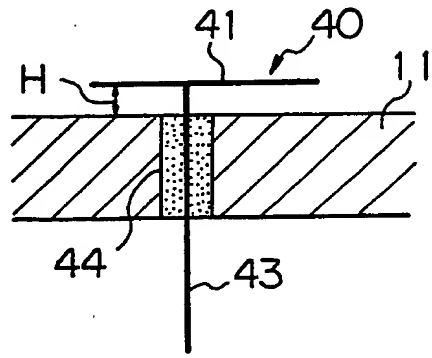


Fig. 9

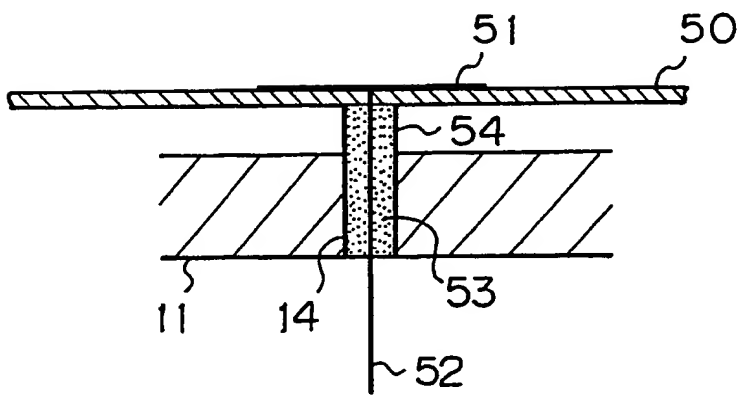


Fig. 10

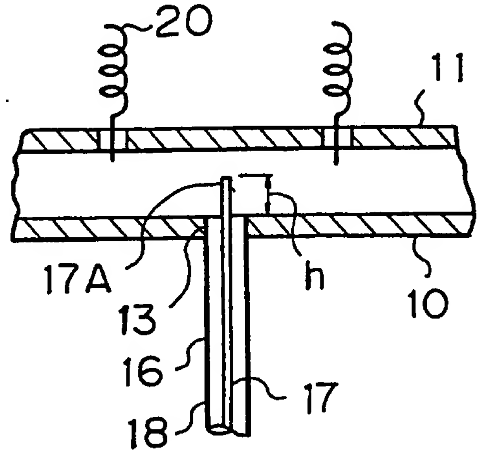


Fig. 11

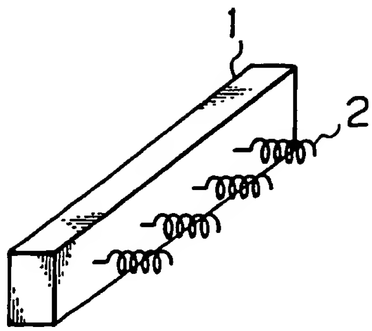


Fig. 12

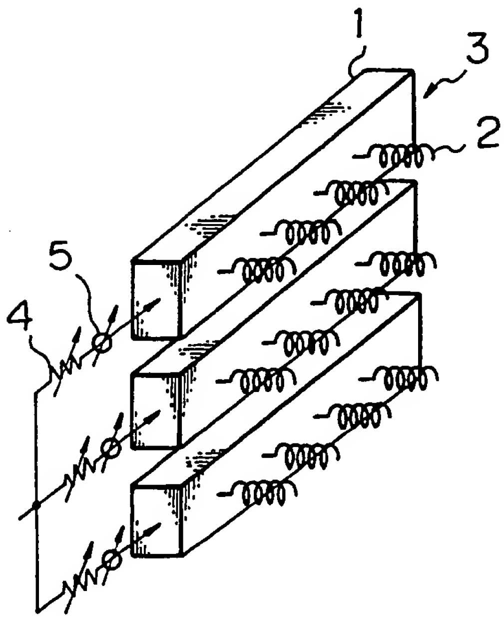
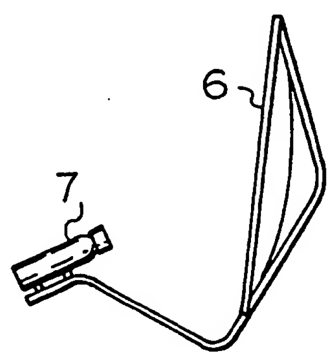


Fig. 13



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A Circular Polarization Antenna System

The present invention relates to an antenna system, in particular, relates to an antenna system for circular polarization for the use in a radar and/or a satellite communication system.

An antenna in a radar and/or a satellite communication system must have high gain and, simultaneously, the size of an antenna system must be small when the mounting space of an antenna system is limited.

Figs.11 through 13 show prior circular polarization antenna systems, which are shown in "Short Helical Antenna Array Fed from a Waveguide" in IEEE transactions on antennas and propagation, vol AP-32, No.8, August, 1984, pages 836-840.

A first prior antenna in Fig.11 has a rectangular waveguide 1 to which an electro-magnetic wave is supplied, and a plurality of helical antenna elements 2 mounted on the waveguide 1 so that each helical antenna elements is electro-magnetically coupled with the waveguide. That structure is called a helical array antenna.

The second prior antenna system in Fig.12 is a circular polarization antenna system having a plurality of helical array antenna systems 3 of Fig.11 in parallel. Each helical antenna system 3 is fed with electro-magnetic wave through an attenuator 4 and a phase shifter 5.

The third prior antenna in Fig.13 is a parabolic antenna having a reflector 6 and a primary radiator 7 positioned at the focal point of the reflector 6.

However, the prior antenna systems have the following disadvantages.

The first prior art of Fig.11 has the disadvantage that the antenna gain is low. In order to obtain the higher antenna gain, a plurality of helical antenna systems must be arrayed as shown in Fig.12. However, the structure of Fig.12 has the disadvantages that the size is large, and the power feed system having attenuators and phase shifters is complicated.

Further, the antenna of Fig.13 has the disadvantage that the space occupied by the antenna system is large, since the primary radiator 7 is separated from the radiator 6.

According to this invention a circular polarization antenna system comprises;

a first flat conductive plate,

a second flat conductive plate positioned parallel to said first flat conductive plate with a spacing less than wavelength, having a plurality of small holes,

a plurality of antenna elements each fixed to said second flat conductive disk at the location of said holes so that an end of each antenna element extends into an antenna body formed between the conductive disks, and

feed means coupled at the centre of said first flat conductive disk to radiate electro-magnetic energy into said antenna body formed between the two disks.

The present invention provides a circular polarization antenna system which is small in size, has a high gain, and is simple in feeding power to the antenna system.

Various examples of antenna systems will now be described and contrasted with the prior art with reference to the accompanying drawings; wherein:-

Fig.1 is a plan view of a circular polarization antenna system according to the present invention,

Fig.2 is a cross sectional view along the line II-II of Fig.1,

Fig.3 is an enlarged view of an antenna element in Fig.1,

Fig.4 is a modificaiton of an antenna element,

Fig.5 is another modification of an antenna element,

Fig.6 is a cross section of Fig.5,

Fig.7 is still another modification of an antenna element,

Fig.8 is a cross section of Fig.7,

Fig.9 is still another modification of an antenna element,

Fig.10 is another embodiment of feed structure according to the present invention,

Fig.11 is a perspective view of a prior circular polarization antenna system,

Fig.12 is a perspective view of another prior circular polarization antenna system, and

Fig.13 is a side view of still another circular polarization antenna system.

The embodiment of the present invention is now

described in accordance with Figs.1 and 2. In those figures, the numeral 10 is a first conductive circular disk, and 11 is a second conductive circular disk. The disks 10 and 11 are positioned parallel to each other so that the spacing between two disks is less than the wavelength of the electro-magnetic wave radiated by the antenna system. The numeral 12 is a circular conductive ring which short-circuits the peripheral portion of the disks 10 and 11 so that a thin cylindrical antenna body is surrounded by two disks and the ring. The radius of the first ring 10 is of course the same as that of the second disk 11, and that of the ring 12.

The hole 13 is provided at the center of the first disk 10 for the central feed line. A plurality of small holes 14 are provided on the second disk 11 for accepting antenna elements 20. A bottom of a conductive matching element 15 in a cone shape is fixed at the center of the second disk 11, and the top of that matching element 15 is coupled with the end of the center conductor line 17 of the coaxial cable 16 which is fixed to said hole 13. Said matching element 15 has a circular cross section, and preferably, the radius or the diameter increases gradually towards the second disk 11. The external conductor 18 of the coaxial cable 16 is electrically coupled with the first conductive disk 10.

Fig.3 shows a helical antenna element 20 which has a coil portion 20a and a linear portion 21 extending in the axis direction of the helical coil 20a at the end of the coil portion 20a.

Each of said holes 14 on the second conductive disks 11 accepts a dielectric chip 22, and said antenna element 20 is electro-magnetically coupled with said cylindrical antenna body which is defined by the two disks 10 and 11 and the conductive ring 12 by inserting said linear portion 21 into said cylindrical antenna body through said dielectric chip 22. The antenna element 20 itself is supported by said dielectrical chip 22.

The gain and the frequency band of said antenna element 20 may be designed as desired by selecting the helical pitch angle of the coil, the circumference length C of the coil, and the number of turns of the coil.

In one embodiment, a plurality of antenna elements 20 are positioned on the second disk 11 on coplanar circles around the center of the disk 11. In other words, the holes 14 are positioned on coplanar circles around the center of the disk 11. In one modification, said antenna elements may be positioned on a spiral curve on the disk 11, or on rectangular coordinates on the disk 11, instead of coplanar circles.

Preferably, a ring shaped wave absorber 23 is

attached on the inside surface of said conductive ring 12 for absorbing the electro-magnetic power around said conductive ring 12.

The electro-magnetic power fed by the coaxial cable 16 propagates in said cylindrical antenna body from the center in the radial direction between said conductive disks 10 and 11, and the power excites the antenna elements 20. The electro-magnetic power is preferably completely transferred to the antenna elements, so that no power reaches the circumferential ring 12. If some power reaches that ring, that power is absorbed by the wave absorber 23 so that no power is reflected by the ring 12.

As described above, the electromagnetic power is radiated through a plurality of antenna elements 20. It should be appreciated that the gain of the antenna is high, since a plurality of antenna elements are used on the disk 11 so that the radiation beam is narrow, and further, the operational frequency band of the present antenna system is wide since the travelling wave current (TEM mode) is distributed on the antenna elements. Further, it should be noted that no attenuator and no phase shifter is necessary for feeding the present antenna and, therefore, the structure of the present antenna is further simplified.

The radiation phase of each antenna element may be adjusted by the positional direction of the initial portion of the helical coil. The radiation power of each helical antenna element depends upon the axial length of the helical antenna element.

When the radius of the disks 10 and 11 is large and no power reaches the peripheral portion of the disks, no wave absorber 23 is necessary.

Fig.4 is a modification of the present invention, in which a dielectric chip 22A engaged with the hole 14 for fixing the antenna element 20 has a flange 25 at one end of the chip. The flange 25 at one end of the chip 22A functions to prevent the short-circuiting of the coil 20a with the conductive disk 11, and to keep the constant spacing T between the end of the coil 20A and the conductive disk 11. Therefore, when a plurality of antenna elements are fixed on the conductive disk 11, the electrical conditions of the antenna elements may be uniform by keeping the uniform spacing T due to the presence of a flange 25.

Figs.5 and 6 show another modification of the present antenna element, in which a spiral antenna 30 is used as an antenna element. The spiral antenna 30 has a flat coil. The feed line 31, which is perpendicular to the flat coil plane, is connected to the center of the

flat coil.

The flat coil 30 is fed through the coaxial chip engaged with the hole 14 of the conductive disk 11. Said coaxial chip has a cylindrical dielectric chip 32 which is covered with the conductive outer conductor 33, and the lead line 31 of the flat antenna element 30 inserted in the center of the dielectric chip 32. The coaxial chip with the dielectric chip 32 and the outer conductor 33 is longer than the thickness of the conductive disk 11, so that the spacing H is provided between the flat plane of the antenna element and the conductive disk. The outer conductor 33 functions to prevent radiation leaking from the coaxial chip.

The circumferential length C of the antenna element 30 is determined between the wavelength and twice of the wavelength. The spacing H between the flat antenna plane and the conductive disk 11 is determined less than half wavelenth, and preferably that spacing is a quarter wavelength for shaping radiation beam.

The modification of Figs.5 and 6 has the advantage that the height of the antenna itself may be short, since the antenna elements are flat ones. The operational frequency range of the modification of Figs.5 and 6 is wide, since the feed signal is a travelling wave signal.

Figs.7 and 8 show still another modification of the

antenna element according to the present invention. The feature of that modification is an antenna element in a flat disk shape. A flat disk antenna element 40 has a circular flat disk 41 with a pair of recesses 42 at the opposite ends of a diameter of the disk 41. The feed line 43 is connected perpendicular to the flat disk 41. The feed line 43 is positioned on the line 42b which is a diameter of the disk 41 with the angle 45° from the diameter 42a between the center of the recesses 42, and the length d bewteen the center of the disk 41 and the coupling point of the feed line 43 is one-third of the radius of the disk 41. The antenna element 40 is fixed to the conductive disk 11 by the feed line 43 inserted in the dielectrical chip 44 in the hole 14 on the disk 11. The spacing H between the flat disk 40 and the conductive disk 11 is determined less than one-tenth of the wavelength.

The modification of Figs.7 and 8 has the advantages that the structure of an antenna element is simple, and the height of the antenna itself is low. However, the operational frequency range is a little narrower as compared with that of the previous embodiments.

Fig.9 shows still another modification of an antenna element according to the present invention. The feature of the modification of Fig.9 is the use of a flat

dielectric substrate 50 positioned parallel to the conductive disk 11. The desired antenna element pattern is deposited on the substrate 50 through a thick film printing process, thin film printing process, or photolithoetching process. The antenna element pattern deposited on the substrate 50 may be either a flat coil pattern as shown in Fig.5, or a flat disk pattern as shown in Fig.7.

The antenna element pattern 51 deposited on the substrate 50 is connected to the feed line 52 which is perpendicular to the substrate 50. The substrate 50 is fixed to the conductive disk 11 by inserting said feed line 52 in the dielectric chip 53 fixed in the hole 14 of the conductive disk 11. The dielectric chip 53 is longer than the thickness of the conductive disk 11, and the outer surface of the dielectric chip 53 is covered with the conductive outer conductor 54 so that the inner conductor 52, the dielectric chip 53 and the outer conductor 54 provide the function of a coaxial cable, so that no radiation is radiated at the feed line portion 52.

The modification of Fig.9 has the advantage that the mass production of the antenna system is possible, since the structure of the antenna elements is simple. The single substrate is used commonly for all the antenna

elements, which are deposited on the substrate through a printing process or photolithoetching process.

Fig.10 shows another embodiment of the present antenna system, and the feature of that embodiment is the presence of the probe 17A which is the extension of the inner conductor 17 of the coaxial cable 16. The electro-magnetic energy is radiated into the cylindrical antenna body surrounded by a pair of conductive disks 10 and 11, and the ring 12 through that probe 17A. So, that probe 17A replaces the cone shaped matching element 15 of Fig.2. The present embodiment has the advantage that the matching condition is adjustable by adjusting the length (h) of the probe 17A.

Although Fig.10 shows the combination of the embodiment of Fig.2 with a probe 17A, it is of couse possible to use a probe 17A instead of a matching element 15 in other embodiments in Figs.4 through 9.

When the present antenna system is used as a satellite television broadcast receiving antenna, the antenna system is coupled with a converter circuit for frequency conversion and signal amplification. That converter may be fixed on the rear surface of the conductive disk 10, and the converter is electrically coupled with the present antenna system through the coaxial cable 16 of the antenna system with no additional

coaxial cable, and no coupling element. Alterntatively, the converter on the rear surface of the conductive disk 10 is coupled with the antenna system through a waveguide.

Although the embodiments show circular conductive disks 10 and 11, and the antenna system is in circular shape, it should be noted of course that the conductive disks 10 and 11 may be rectangular, and/or polygonal.

CLAIMS

1. A circular polarization antenna system comprising;

a first flat conductive plate,

a second flat conductive plate positioned parallel to said first flat conductive plate with a spacing less than wavelength, having a plurality of small holes,

a plurality of antenna elements each fixed to said second flat conductive disk at the location of said holes so that an end of each antenna element extends into an antenna body formed between the conductive disks, and

feed means coupled at the centre of said first flat conductive disk to radiate electro-magnetic energy into said antenna body formed between the two disks.

2. A circular polarization antenna system according to claim 1, further comprising a conductive ring short-circuiting peripheral portions of said first disk and said second disk.

3. A circular polarization antenna system according to claim 2, wherein a wave absorber is provided on an inner surface of said conductive ring for absorbing electro-magnetic energy around said conductive ring.

4. A circular polarization circular antenna system according to any one of the preceding claims, wherein a conductive matching element with a cone shaped cross-section is provided at centre of said second conductive disk and a sharp end of said matching element is connected to the end of the inner conductor of said feed means.

5. A circular polarization antenna system according to any one of claims 1 to 3, wherein a probe is extended into said antenna body between said conductive disks from said feed means.

6. A circular polarization antenna system according to any one of the preceding claims, wherein a dielectric

insert is provided in said holes on the second flat conductive disk, and said antenna elements are supported by the dielectric inserts.

7. A circular polarization antenna system according to claim 6, wherein the inserts include a flange overlying the second flat conductive disk.

8. A circular polarization antenna system according to claim 6 or 7, wherein the length of said dielectric insert is longer than the thickness of the second flat conductive disk, and the dielectric insert is surrounded by an outer conductor.

9. A circular polarization antenna system according to any one of the preceding claims, wherein said antenna element is a helical coil with its axis normal to said second flat conductive disk.

10. A circular polarization antenna system according to any one of claims 1 to 8, wherein said antenna element is a flat spiral positioned in a plane parallel to said second flat conductive disk.

11. A circular polarization antenna system according to claim 10, wherein the circumference length of the flat spiral is between a wavelength and twice a wavelength, and the spacing H between said flat coil and said second conductive disk is less than half a wavelength.

12. A circular polarization antenna system according to any one of claims 1 to 8, wherein said antenna element is a flat conductive disk having a pair of diametrically opposite recesses.

13. A circular polarization antenna system according to claim 12, wherein said flat conductive disk of an antenna element is fed at point which is on a diameter which intersects the diameter between the recesses, at an angle of 45° and spaced from the centre of the disk by essentially one-third of radius of the disk.

14. A circular polarization antenna system according to any one of the preceding claims, wherein a dielectric substrate is provided parallel to said second flat conductive disk on which the antenna elements are mounted.

15. A circular polarization antenna system substantially as described with reference to Figures 1 to 10 of the accompanying drawings.

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